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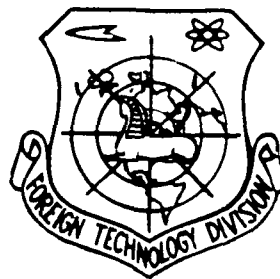
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# FOREIGN TECHNOLOGY DIVISION



HERALD OF THE LENINGRAD ORDER OF LENIN ELECTRICAL-ENGINEERING  
INSTITUTE IMENI V.I. UL'YANOV (LENIN)

(Selected Articles)



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# HUMAN TRANSLATION

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# U. S. BOARD ON GEOGRAPHIC NAMES transliteration SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	<i>А а</i>	A, a	Р р	<i>Р р</i>	R, r
Б б	<i>Б б</i>	B, b	С с	<i>С с</i>	S, s
В в	<i>В в</i>	V, v	Т т	<i>Т т</i>	T, t
Г г	<i>Г г</i>	G, g	У у	<i>У у</i>	U, u
Д д	<i>Д д</i>	D, d	Ф ф	<i>Ф ф</i>	F, f
Е е	<i>Е е</i>	Ye, ye; E, e*	Х х	<i>Х х</i>	Kh, kh
Ж ж	<i>Ж ж</i>	Zh, zh	Ц ц	<i>Ц ц</i>	Ts, ts
З з	<i>З з</i>	Z, z	Ч ч	<i>Ч ч</i>	Ch, ch
И и	<i>И и</i>	I, i	Ш ш	<i>Ш ш</i>	Sh, sh
Й й	<i>Й й</i>	Y, y	Щ щ	<i>Щ щ</i>	Shch, shch
К к	<i>К к</i>	K, k	Ъ ъ	<i>Ъ ъ</i>	"
Л л	<i>Л л</i>	L, l	Ы ы	<i>Ы ы</i>	Y, y
М м	<i>М м</i>	M, m	Ь ь	<i>Ь ь</i>	'
Н н	<i>Н н</i>	N, n	Э э	<i>Э э</i>	E, e
О о	<i>О о</i>	O, o	Ю ю	<i>Ю ю</i>	Yu, yu
П п	<i>П п</i>	P, p	Я я	<i>Я я</i>	Ya, ya

\*ye initially, after vowels, and after ъ, ь; e elsewhere.  
When written as ѐ in Russian, transliterate as yě or ě.

## RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	$\coth$	arc cth	$\coth^{-1}$
sec	sec	sch	scsch	arc sch	$\operatorname{sech}^{-1}$
cosec	csc	csch	csch	arc csch	$\operatorname{csch}^{-1}$

Russian English

rot curl  
lg log

## GRAPHICS DISCLAIMER

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HERALD OF THE LENINGRAD ORDER OF LENIN  
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IMENI V.I. UL'YANOV (LENIN)

(selected articles by Yegorov, Yu.V. and Naumov, K.P.,  
pages 113-120)

1. Yegorov, Yu.V., Naumov, K.P., Conversion of space-recorded codes into electrical by the optical method (113)
2. Yegorov, Yu.V., Naumov, K.P., Correlation processing of periodic binary pseudorandom codes by the optical method (115)
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## CONVERSION OF SPACE-RECORDED CODES INTO ELECTRICAL BY THE OPTICAL METHOD

Yegorov, Yu.V., Naumov, K.P.

Correlation systems of the optical type [1, 2, 3], which recently have been used extensively for processing radar signals, can be used for the generation of complex electric signals. In a system of such a type (Fig. 1) the electric signal on the output of the photodetector is obtained as a result of the correlation of the signal which is spatially recorded on transparency T. The signal has a short radio pulse which is passing in a transparent sound duct of an ultrasonic light modulator (UZMS). Here the radio pulse "reads" the space signal from the transparency, converting it into a time [signal].

As is known [3], in the system which is shown in Figure 1 the output voltage will be

$$\begin{aligned} u_{out}(\tau) &= A \int u_1(x) u_2^*(x-\tau) dx \cdot \cos[\omega_0 \tau + \theta(\tau)] = \\ &= A \gamma_{12}(\tau) \cos[\omega_0 \tau + \theta(\tau)], \end{aligned}$$

where  $u_1(x)$ ,  $u_2(x)$  - complex envelopes of the signal and the transparency;  $\gamma_{12}(\tau)$  - envelope of the correlation function of the initial signals;  $\omega_0$  - frequency of the carrier signal in the UZMS.

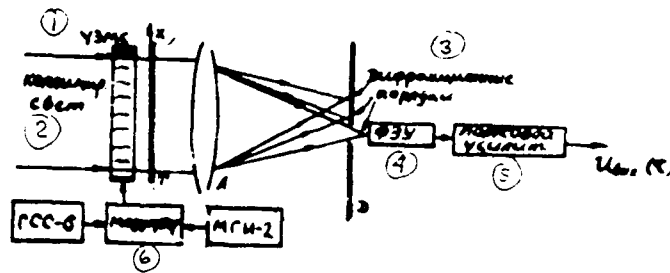


Figure 1.

Key: (1) UZMS; (2) Collimated light; (3) Diffraction orders;  
(4) FEU; (5) Band amplifier; (6) Modulator.

It is evident that undistorted read-out would be possible only when  $u_2(x) = (x)$ : if read-out takes place with a pulse of duration  $t_0$ , then, as can be obtained readily from the correlation integral, the minimum duration of the front of the signal which is read out is equal to  $t_0$ , and the minimal distance between two successive pulses (interruptions) of the transparency should be no less than  $2\sqrt{t_0}$ .

An experimental investigation was made of the read-out of a signal from a transparency which was made by the photo method in the form of an amplitude diffraction grating, manipulated in phase relative to the space carrier (5.1 mm) in conformity with the law of pseudorandom binary sequence with base 7; the overall length of the transparency was 171.45 mm. Figure 2 shows in a strongly magnified form a small portion of the transparency, illustrating its structure. The read-out pulse had a carrier of 6.35 MHz, pulse duration varied from 1  $\mu$ s to 0.3  $\mu$ s. The read-out was made of different sectors of the transparency with a length from 20 mm to 171.45 mm.



Figure 2.

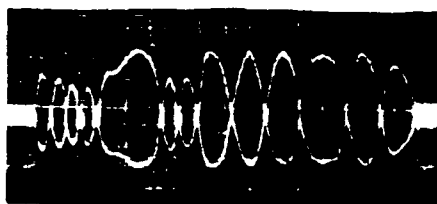


Figure 3.

Figure 3 shows the oscillogram of the signal which was read out from an aperture of 31 mm with a pulse  $t_0 = 0.5 \mu\text{s}$ . The result of the read-out is a phase-manipulated radio signal, the changes of state of phase of the carrier (6.35 MHz) conform to the passing of the envelopes through zero, and the duration of the pulse fronts is equal to  $t_0 = 0.5 \mu\text{s}$  (one large division on the oscillogram corresponds to  $2.5 \mu\text{s}$ ).

The first four pulses (on the left) correspond to the four phase interruptions on that particular segment of the transparency (Fig. 2).

The experiment confirms the possibility of generating electric signals by the optical method, and the structure and type of signal generated are determined only by the structure and type of



transparency. This distinguishes this method of signal generation favorably from the known radio-engineering methods.

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# CORRELATION PROCESSING OF PERIODIC BINARY PSEUDORANDOM CODES BY THE OPTICAL METHOD

Yegorov, Yu.V., Naumov, K.P.

Optical systems of correlation processing of radio signals [1, 2, 3] have advantages over radio engineering in their multichanneling (resulting from the two-dimensional nature of the first) and simplicity in obtaining correlation functions of complex signals. The results of an experiment on the correlation processing of a binary pseudorandom code are described in this work.

Figure 1 shows the layout of the installation.

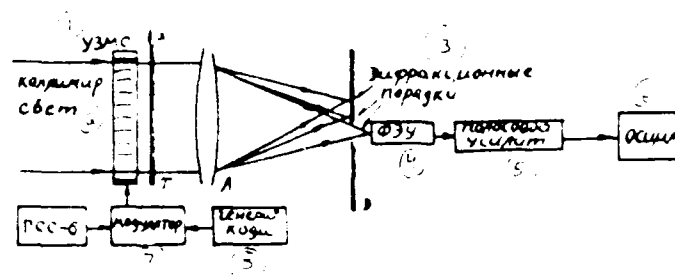


Figure 1.

Key: (1) UZMS; (2) Collimated light; (3) Diffraction orders;  
(4) FEU; (5) Band amplifier; (6) Oscilloscope; (7) Modulator;  
(8) Code generator.

The code generator forms a binary sequence of pulses according to the rule [4]:

$$d_i = -d_{i-7}d_{i-8}d_{i-9}d_{i-10}d_{i-11}d_{i-12}d_{i-13},$$

where  $i=7, 8, 9$ , and  $d_7=d_8=\dots=d_0=-1$ ,  $d_1=+1$ .

The duration of the code is equal to  $127 t_0$ , where  $t_0$  - duration of cycle, equal to  $1 \mu s$ . After the balance modulator a phase-manipulated radio signal ( $f$  of carrier =  $6.35 \text{ MHz}$ ) is obtained which enters the ultrasonic light modulator (UZMS). The modulator is a cuvette with alcohol in which a piezoceramic element (type TsTS-19) excites ultrasonic waves. Figure 2 shows the oscillogram of a portion of the signal which is being processed. In conformity with the code the transparency was made in the form of an amplitude diffraction grating, phase-modulated relative to the space carrier and equal to  $5 \text{ 1/mm}$ .

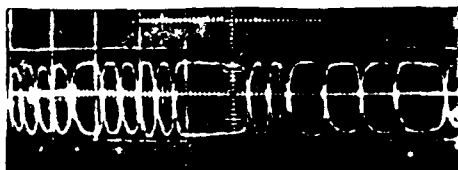


Figure 2.

In the optical system shown in Figure 1 the voltage on the output of the band amplifier is equal to [3]:

$$\begin{aligned} u_{\omega_0}(\tau) &= A \int u_1(x) u_2^*(x-\tau) dx \cos[\omega_0 \tau + \theta(\tau)] = \\ &= A \gamma_{12}(\tau) \cos[\omega_0 \tau + \theta(\tau)], \end{aligned}$$

where  $u_1(x)$  and  $u_2(x)$  - complex envelopes of the signal of the UZMS and the transparency;  $\gamma_{12}(\tau)$  - envelope of the correlation function of these signals;  $\omega_0$  - carrier frequency.

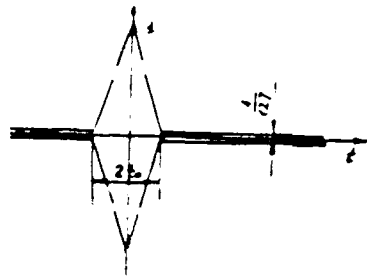


Figure 3.

The theoretical form of the envelope of the autocorrelation function of the radio signal, manipulated in phase by a pseudorandom binary sequence with a code base seven [4], is shown in Figure 3.

The correlation function of the signal and the transparency which was obtained experimentally is shown in Figure 4. The observed difference in the experimental correlation functions and theoretical is explained by the following factors: the imperfect form of the radio signal (Fig. 3) nonideal conformity of the transparency to the signal the filtering properties of the band amplifier and the aberrations of

the optical system. The influence of these factors on the correlation function can be calculated theoretically.



Figure 4.

Thus the experiment confirms the possibility of correlation processing of complex lengthy radio signals (signal length  $127 \mu\text{s}$  against  $0.2 \mu\text{s}$  in work [3]) by the optical method. With replacement of lens  $\nu$  by an astigmatic pair the system is converted to multichannel, and the transition to the processing of another signal is connected only with replacement of the transparency.

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## DIFFRACTION SPATIAL OPTICAL LIGHT MODULATOR WITH CROSSED ULTRASONIC FIELDS

Yegorov, Yu.V., Naumov, K.P.,

Diffraction ultrasonic light filters (UZMS) are the most effective means for entering radio signals into operational optical processing systems. In this work a review is made of the technical feasibility of an astigmatic optical processing system using crossed UZMS instead of the single-dimensional modulator which is usually used.

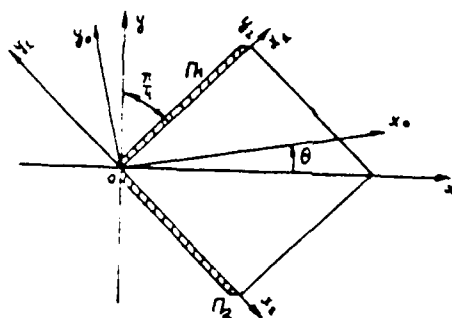


Figure 1.

Figure 1 shows the layout of the modulator, the modulating field of which is formed by two orthogonally crossed ultrasonic traveling waves with envelopes  $u_1$  and  $u_2$ , excited by converters  $P_1$  and  $P_2$ . In the accepted system of coordinates the envelopes  $u_1$  and  $u_2$  have the form of waves

$$u_1(t_1 + \frac{y_1}{v}) , \quad u_2(t_2 - \frac{y_2}{v}). \quad (1)$$

The collimated light, directed perpendicular to the plane of the modulator, is modulated by waves (1) and enters the lens astigmatic pair with axes  $x_0, y_0$  such that  $x_0$  - the coordinate along which the Fourier transform is fulfilled, and  $y_0$  - the coordinate, relative to which the actual image is formed in the plane of the photodetector. If the system of coordinates  $(x_0, y_0)$  is turned relative to the system  $(x, y)$  by the angle  $\theta$ , then after the conversions of the coordinates the waves (1) are reduced to the form:

$$u_1\left(\frac{l_1 + cy_0 - sx_0}{v_g}\right); \quad u_2\left(\frac{l_2 - sy_0 - cx_0}{v_g}\right), \quad (2)$$

where  $s = \sqrt{2} \sin(\xi - \theta)$ ,  $c = \sqrt{2} \cos(\xi - \theta)$ ,  $l_{1,2} = t_{1,2} v_g$

$v = \frac{v_0}{\sqrt{2}}$  - speed of ultrasound.

Under the assumption of the properties indicated for the optical system it can be shown that the optical or electrical signal recorded on the output is proportional to the integral

$$J_{12}(y_0) = -v_g \int_A u_1(\tau + st) u_2(\tau + ct) d\tau \quad (3)$$

Here:  $t = -\frac{x_0}{v_g}$ ,  $\tau_1 = \frac{1}{v_g}(l_0 + cy_0)$ ,  $\tau_2 = \frac{1}{v_g}(l_2 - sy_0)$ ,

$A$  - aperture of the optical system.

The integral transformation (3) which is made by the optical system has a different mathematical meaning with different methods of indication of light distribution.

Actually, if  $1/\theta = 0$  (i.e.,  $S=1$ ,  $C=1$ ), then

$$J_0(\tau) = -v_g \int_A u_1(t) u_2(t+\tau) dt \equiv u_1 * u_2 = R_{12}(\tau), \quad (4)$$

where  $\tau = (t_2 - t_1) - \frac{\sqrt{x}}{v_g} y_0$ .

Thus in this case the distribution of light in the output plane will be described by a function of mutual correlation of the envelopes  $u_1$  and  $u_2$ , the maximum of which has the coordinate  $\frac{\sqrt{x}}{v_g} y_0$ .

If  $2/\theta = \frac{1}{2}$  ( $S=-1$ ,  $C=1$ ), then in the case of using spatial photoelectric integration in the photodetector and band-pass filtration the envelope of the radio signal will be proportional to the integral [3]:

$$J_{11} = v_g \int_A u_1(t') u_2[(t_1 - t_0) - t'] dt' \equiv u_1(t) \otimes u_2(t), \quad (5)$$



which is the convolution function of the envelopes. It is interesting that in this case the dependence of the integral on  $y_0$  disappears.

If  $3/4 - \pi/4 < \theta \leq \pi/4$  ( $0 < c < \sqrt{2}$ ;  $\sqrt{2} > \xi > 0$ ), then the light distribution on the output will be described by the integral

$$J_{11}(y_0) = -\frac{\sqrt{2}}{c} \int_A u_1(mt') u_2 \left[ t' + (t_2 - t_1 - \frac{\xi}{\sqrt{2}} y_0) \right] dt' \quad (6)$$

where  $t' = ct$ . Consequently the distribution is determined by the function of mutual correlation of  $u_1$  and  $u_2$  with the variable scale coefficient  $m$  relative to the variable  $t$ , and

$$m = \xi/c = t_2 (\pi/4 - \theta).$$

Thus the use of the device described in an optical system makes it possible: 1/ to carry out correlation processing of radio signals with a spatial separation of the output signal (including in the case of variable time scales of the signals); 2/ to distinguish the time signal which is proportional to the convolution function of the signals (or the function of mutual correlation of the two "mirror" signals).

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